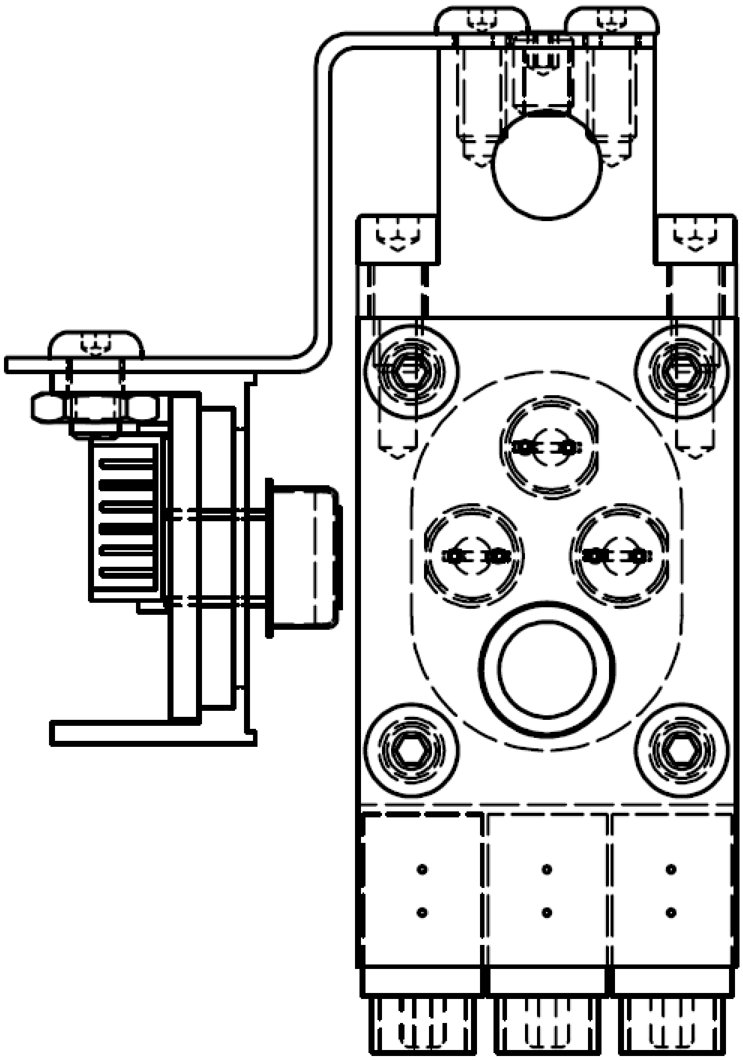
MPC Run 08 Monitoring System

John Koster, Mickey Chiu, Andrey Kazantsev



Contents

1 Purpose

The purpose of this document is to describe the MPC LED system and understand its data from Run 08. Significant reduction in the LED signals measured by towers over Run 08 with little or no reductions in the system's pin diode monitors indicate an aging effect in the towers.

Where possible, detector-wide summary plots are provided but supplemental files contain more raw tower-by-tower plots. Since the MPC(S,N) contain (196,220) towers, flipping through the more raw presentation isn't as sleep inducing a process as it would be for the PbSc or PbGl.

Note: the term "fee576ch", used frequently in this writeup, is a unique tower identifier which stems from our use of 4 central arm Emcal FEM's. Towers 0-287 are in the South and 288-575 are in the North.

2 Hardware Description

2.1 Muon Piston Hole

The Muon Piston Calorimeters sit in 45 cm diameter holes in the North and South Muon Pistons with the beampipe running through the center of each detector. In addition to the beampipe the North MPC also contains a beampipe support. See figures 1-3 for visuals.

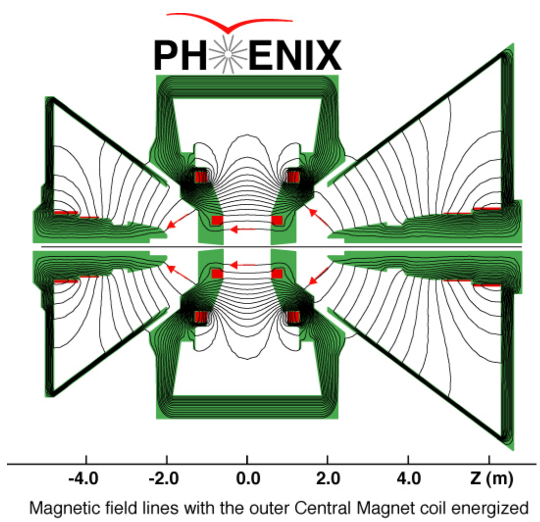


Figure 1: PHENIX Magnets

Each hole is expected to be well shielded from backgrounds moving from the Muon Identifiers towards the interaction point because of the return yokes. The north return yoke is 387.4 cm (220 X_0, 23.1 nuclear interaction lengths) while the south return yoke is 256.9 cm (146.2 X_0, 15.3 nuclear interaction lengths).[1]

[1] Piston dimensions from: http://www.phenix.bnl.gov/WWW/INTEGRATION/ME&Integration/Drawings/RD0002-0000002h.pdf, Nuclear properties of iron from: http://pdg.lbl.gov/AtomicNuclearProperties/

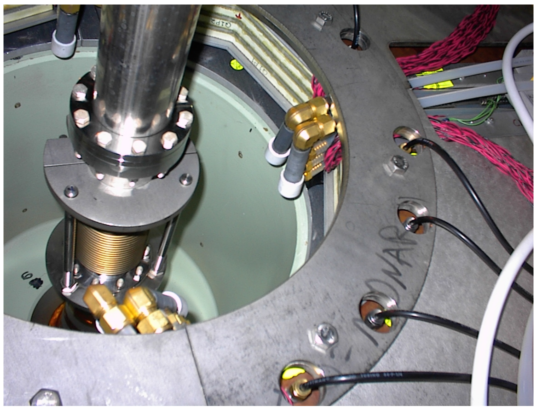


Figure 2: South Piston Hole

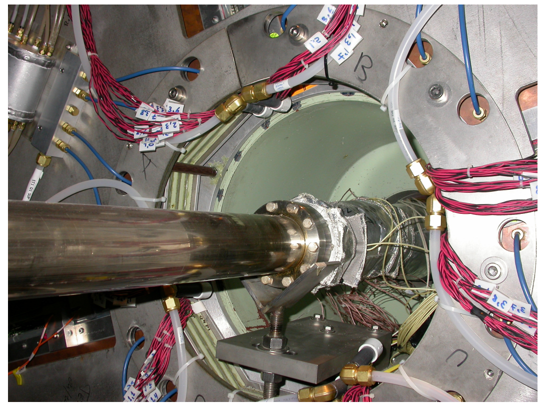


Figure 3: North Piston Hole

2.2 Tower

The basic unit of the MPC is a $PbWO_4$ crystal from the Kurchatov Institute coupled to an Avalanche Photo Diode from Hiroshima University with Dow Corning RTV 3145 glue. An exploded tower assembly is shown in figure 4.

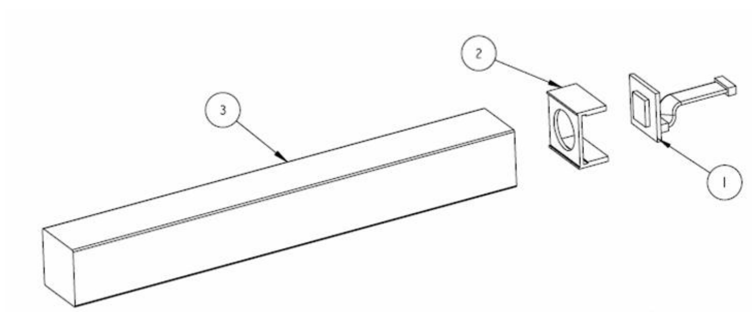


Figure 4: MPC Tower Assembly: 1) Crystal, 2) APD Holder, 3) Avalanche Photodiode (APD)

The crystal is first wrapped with Tyvec[2], then a thin aluminum foil, and finally a Monokote[3] wrap for light-tighting.

The APD and crystal have known dependencies on temperature which will be seen in this note.

[2]FedEx envelopes are typically made of Tyvek

[3]Plastic wrap used for making the skin for model airplanes. Coincidentally, its manufacturer is based in Champaign, IL

2.3 Run 06

The South MPC was active for the later portions of the 2006 polarized proton run and had noise problems in approximately 1/4 of its acceptance (lower right quadrant of figure 5). See 62 GeV A_N analysis note for details.

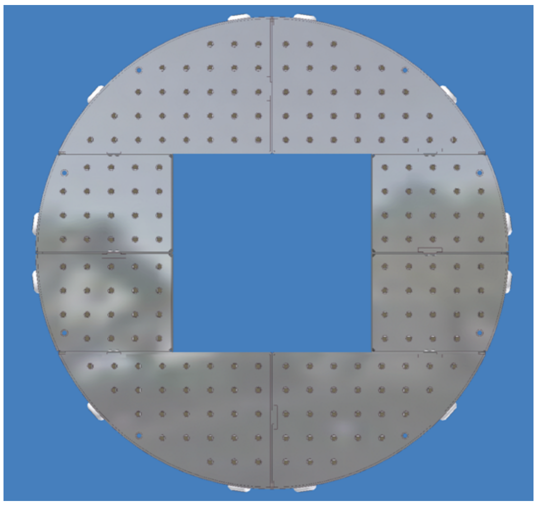


Figure 5: South MPC Run 06, 192 towers

Figure 6: North MPC Run 06, not implemented

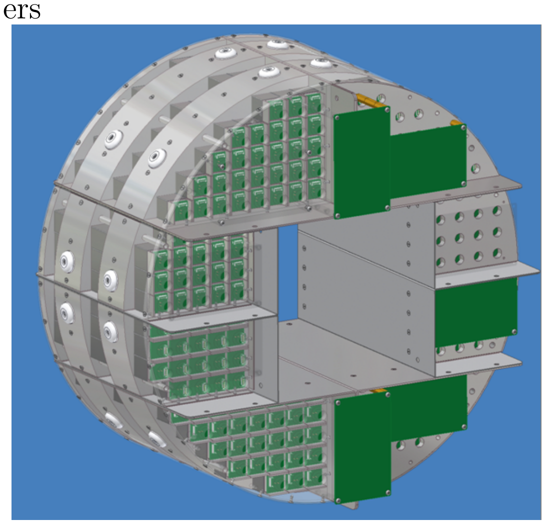


Figure 7: South MPC Run 06, Alternate view

2.3.1 Monitoring System

The monitoring system consisted of a led pulser, fanout boards and one LED for every tower. Since each crystal had a single LED pulsing it the systems's design made it impossible to disentangle fluctuations in LED intensity from tower effects. See figure 8 for a simple diagram of the system.

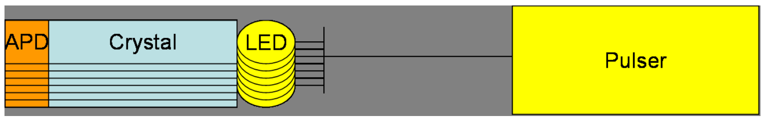


Figure 8: Run 6/7 Monitoring Diagram

2.4 Run 07

The North MPC is installed. The North MPC makes use of front-loading installation scheme which is applied to a redesigned South MPC for run 08.

2.4.1 Monitoring System

The same monitoring scheme from run 06 was used for the North MPC in run 07.

2.5 Run 08

An improved South MPC is built and installed with 4 extra crystals making use of a front loading installation scheme. Additionally, a new monitoring system is installed on both the North and South detectors.

2.5.1 Monitoring System

The same pulsers from Run 6 and 7 are used to power LED's which sit in teflon "homogenizers". Plugged into the homogenizer are fiber bundles which distribute the light to individual towers. Each MPC has 6 homogenizers (12 total). Two LED's are installed in each homogenizer: one of blue light and the other of red light. The aim of the two types of LED's is to disentangle crystal damage from APD or other types of aging effects.

Pin diodes are mounted next to small holes in the homogenizer walls which monitor the amount of light emitted by the LED's. In this way the pin diodes act as a monitoring system for the monitoring system. If the LED were to reduce light output over time due to radiation damage or change light output vs. temperature, then (in principle) the pin diodes could be used to correct for these effects. This of course assumes that the pin diode is insensitive to whatever affects the LED's. The same pin diode as the PbGl: Hamamatsu S1223-01[4] is used.

[4]http://sales.hamamatsu.com/assets/pdf/parts_S/S1223.pdf

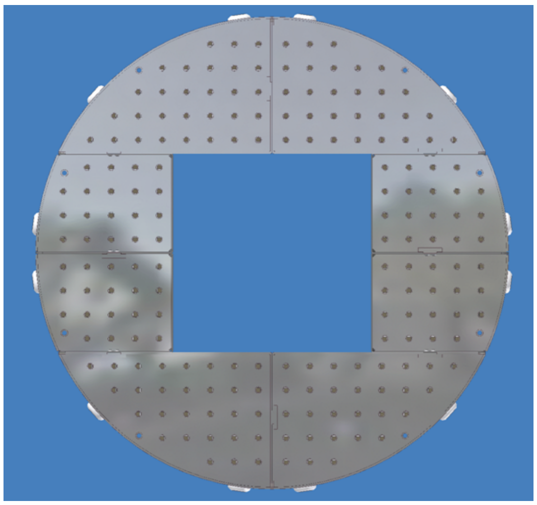


Figure 9: South MPC Run 07, 192 towers (same as run 06)

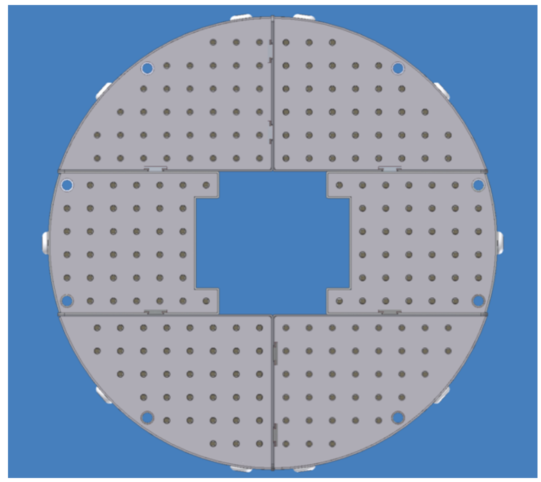


Figure 10: North MPC Run 07, 220 towers

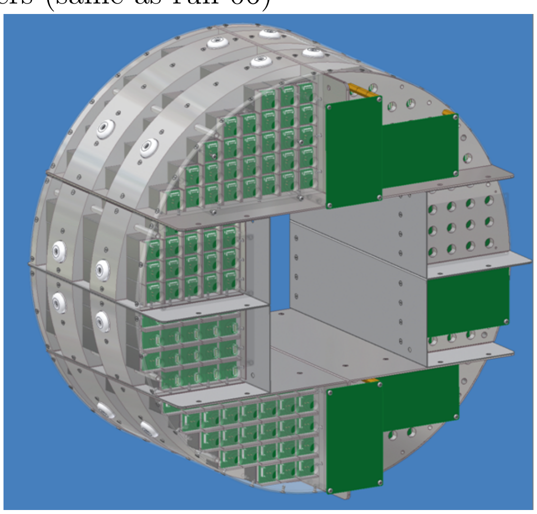


Figure 11: South MPC Run 07, Alternate view (same as run 06)

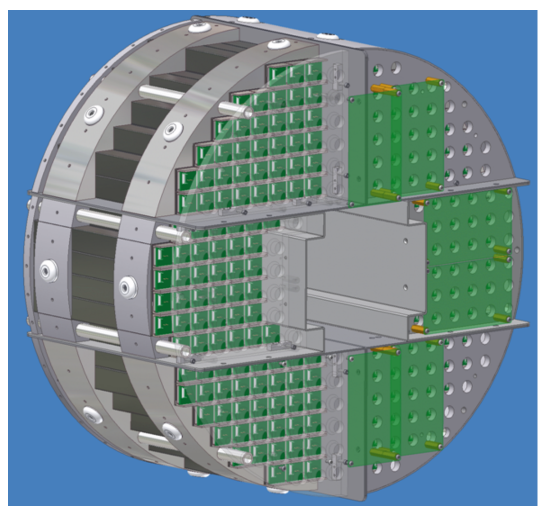


Figure 12: North MPC Run 07, Alternate view

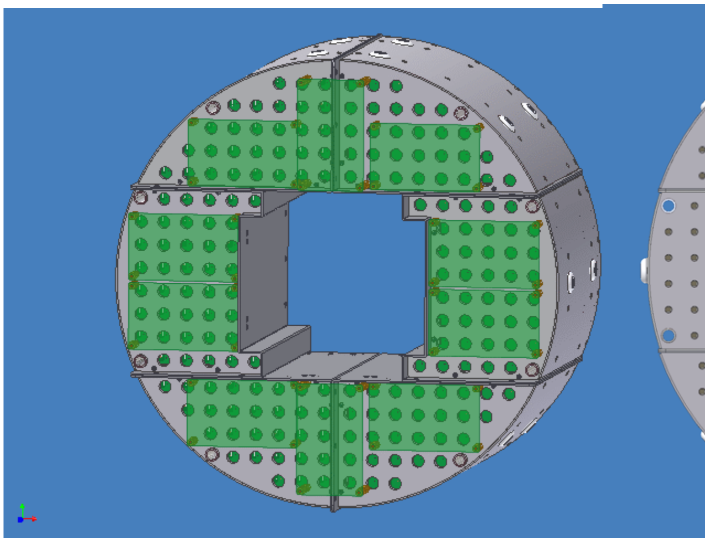


Figure 13: South MPC Run 08, 196 towers

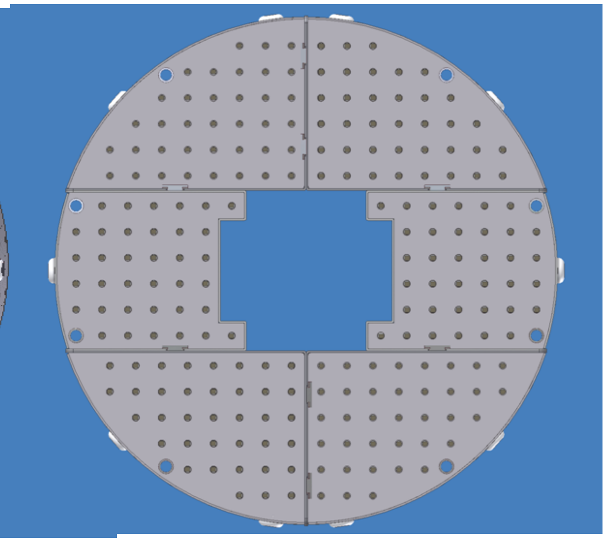


Figure 14: North MPC Run 08, 220 towers (same as run 07)

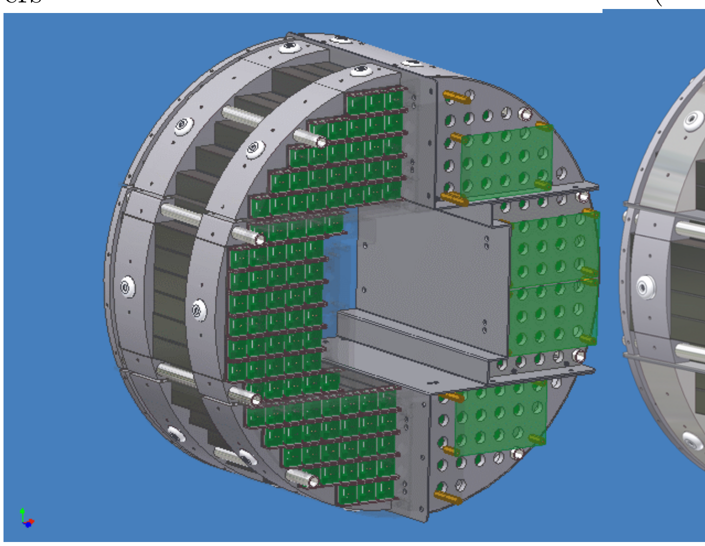


Figure 15: South MPC Run 08, Alternate view

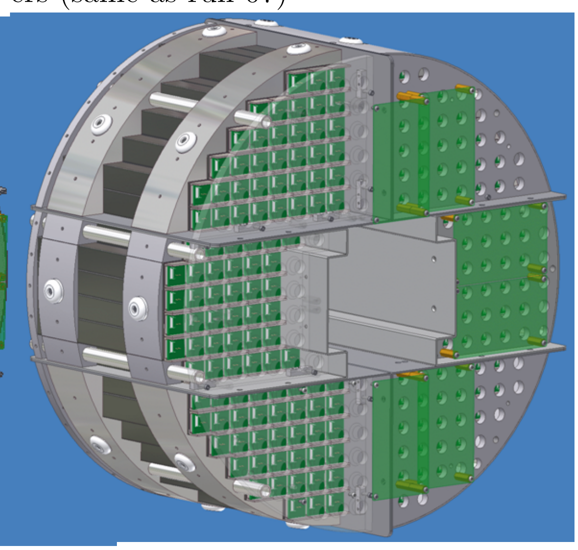


Figure 16: North MPC Run 08, Alternate view (same as run 07)

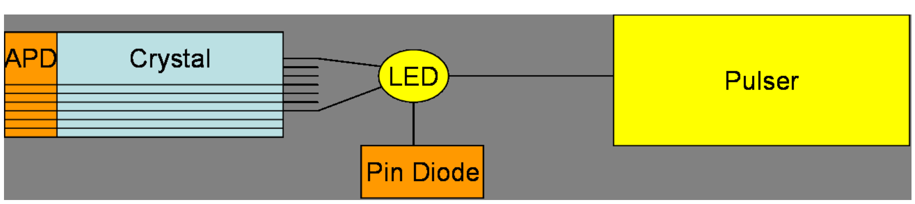


Figure 17: Run 8- Monitoring Diagram

The pin diodes are read out with the same readout chain as the avalanche photodiodes. See figure 17 for a simple diagram of the system and an associated table with fee576ch numbers for each pin diode.

Fee576ch	Arm	Location
60	South	Top Left
61	South	Middle Left
62	South	Bottom Left
86	South	Top Right
85	South	Middle Right
84	South	Bottom Right
348	North	Top Left
349	North	Middle Left
350	North	Bottom Left
374	North	Top Right
373	North	Middle Right
372	North	Bottom Right

3 Temperature of Detector

Several thermocouples are placed in and around each MPC to monitor temperatures. The thermocouples are read out using the ADAMs and stored in a mysql database. The data was dumped into text files after the run, and plotted against timestamp. These plots are available in Appendix A.

The correlated dips in temperature between both arms are postulated to correspond to periods when the muon magnet currents are brought to standby. The long temperature turn-on curve seems consistent with this hypothesis.

4 LED Triggered Analysis

4.1 Data Selection

PPG data files of the form: EVENTDATA_ppg_P00-0000[RUNNUMBER]-0000.PRDFF were run over using a modified version of the PbGl online calibration software package. As of 2008-06-22 all data could be found in the following locations:

Network	Directory
1008	/common/p{0,1,2,3,4}/phnxrc/lvl2_store/
1008	/common/{a,b,c,d}6/eventdata/
RCAS	/phenix/bdata01/phnxreco/run8dAuppg/

The total number of runs (dA+pp) used in this analysis is: 921.

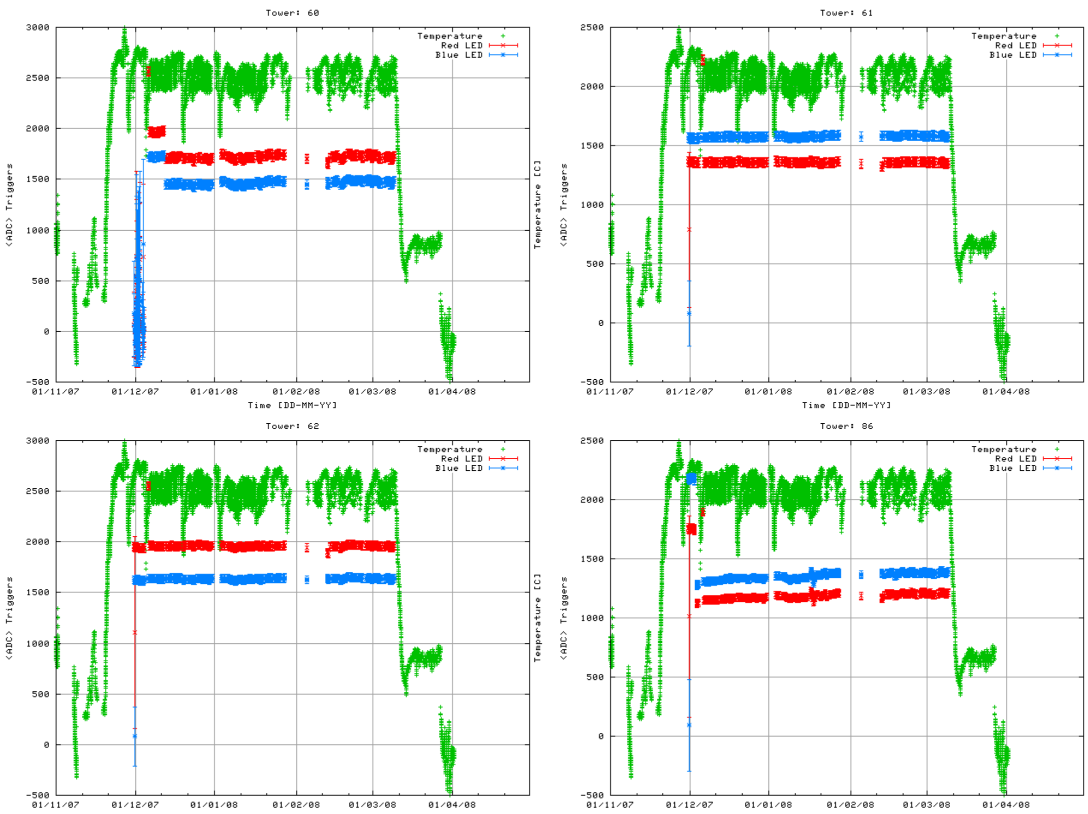
4.2 Description of Analysis

For each file and trigger type (Blue and Red LED) an average and RMS ADC [5] are calculated for each tower.

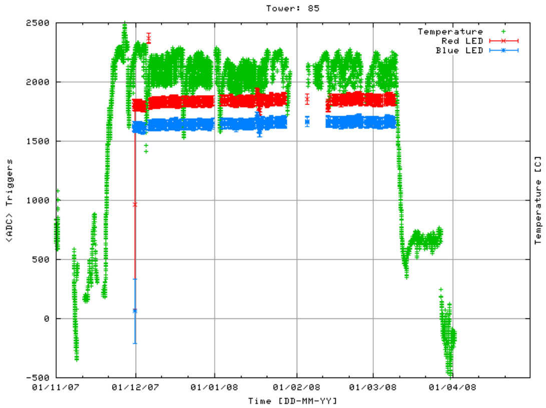
4.3 Stability of Delivered Light

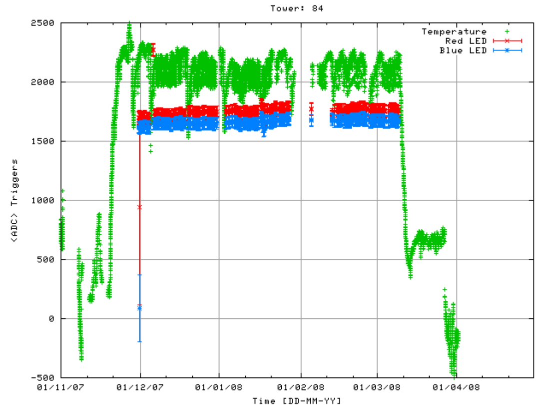
To convince the reader that the amount of light delivered by the monitoring system is stable with time, the 12 pin diode signals will be presented first followed by tower signals.

4.3.1 South MPC Pin Diode Plots

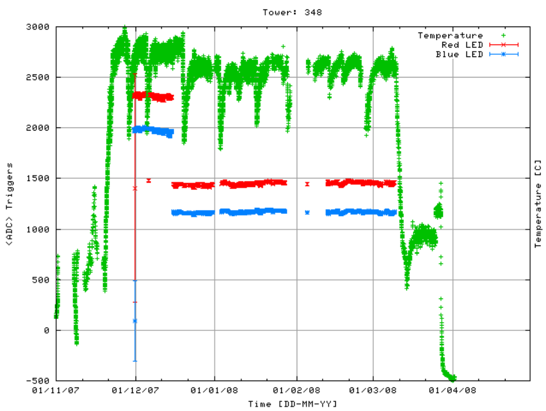


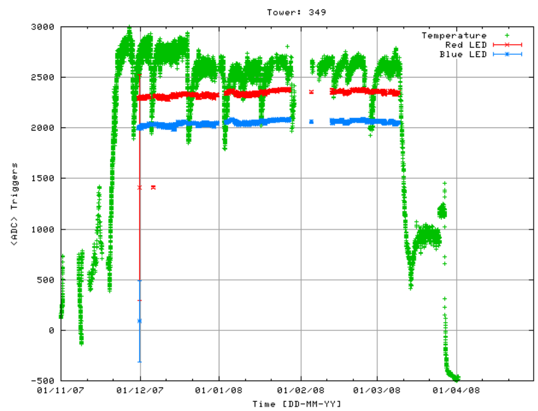
[5] In this analysis, ADC≡Post-Pre-Pedestal

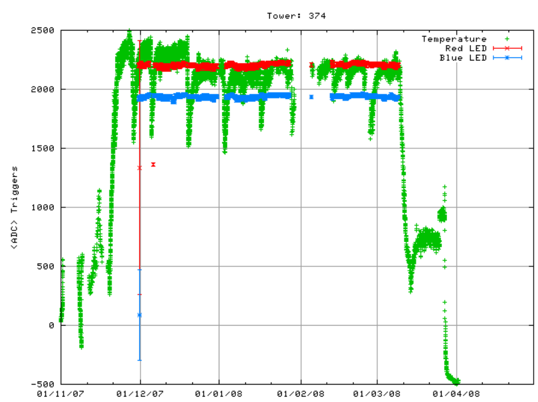


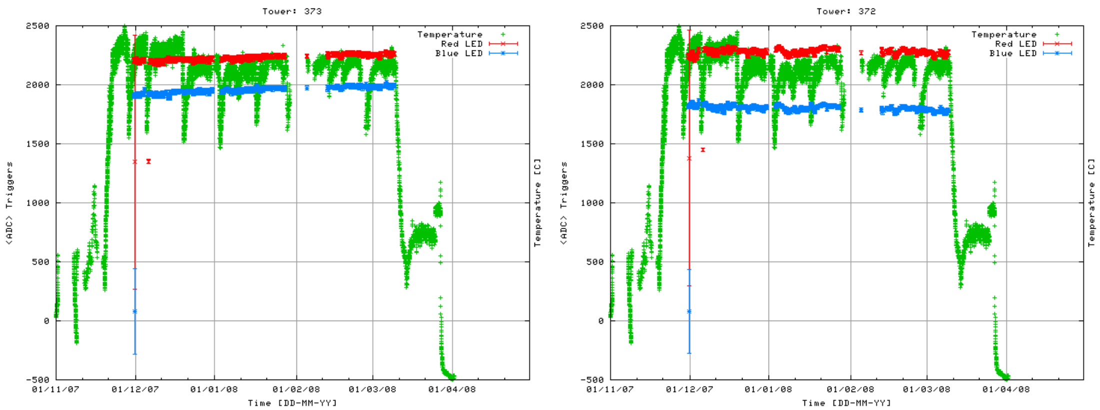


4.3.2 North MPC Pin Diode Plots









4.3.3 Discussion

Neglecting shifts at the beginning of the run, the pin diode signals appear to be stable over the run and insensitive to temperature. Some of the shifts are due to tweaking in the system and were done before the declaration of physics data-taking mode.

4.4 Tower LED Data

Significant reduction in measured LED signals can be seen in every MPC tower over run 8 as shown in

`supplementary/MpcCalTemperature-999.pdf`

An example plot from this pdf is shown in figure 18.

4.4.1 dADC/dt

To get a sense of the detector-wide behavior each tower's set of run averaged LED signals is fit with a linear function ADC=a+b×TIME. Where b is the change in ADC per second (dADC/dt) [s^{-1}]), and a's interpretation is an extrapolated MPC ADC to the start of UNIX time (January 1, 1970). One fit per tower is done over the four datasets: blue dA, red dA, blue pp, and red pp. The fit parameter b is shown in figures 19 through 22 in units of [ADC/month^{-1}] for the four data sets.

The pin diodes were excluded from the analysis, as well as tower #95 which was not instrumented for run 8.

4.4.2 (dADC/dt) / ADC$|_{dAStart}$

To remove tower-by-tower gain fluctuations and the absolute difference in signal strengths between LED's, the percentage change per month (β) was found from

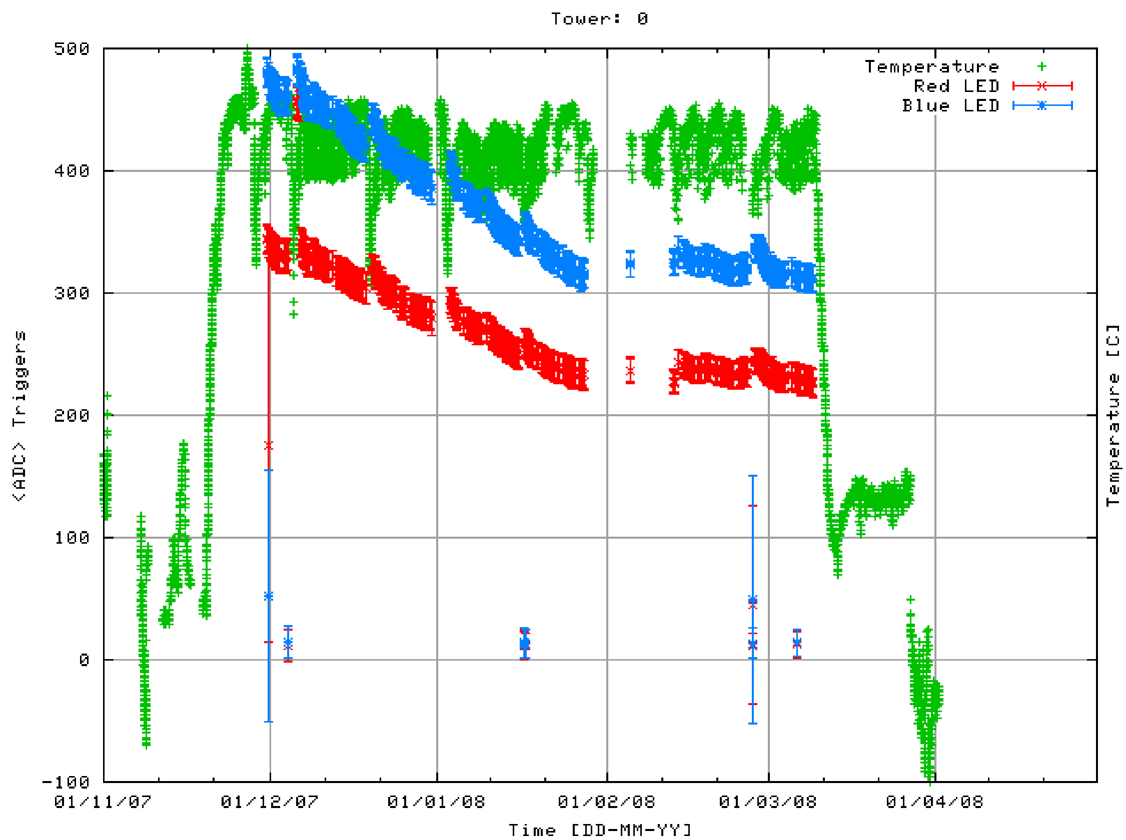


Figure 18: Red and blue points correspond to run averaged ADC's for tower 0. The color of the point corresponds to the color of the LED. Temperature is shown in green

the fit parameters. Again, the pin diodes and tower #95 were excluded from the analysis.

$$\beta = \frac{b \times 60 \times 60 \times 24 \times 30}{a + b \times UNIXTIME(dA_{START})}$$

Results are shown in figures 23 through 26.

4.4.3 $d(\mathbf{ADC}_{Blue}/\mathbf{ADC}_{Red})$ / $d\mathbf{t}$

2 new data sets were formed from the 4 previously mentioned data sets by dividing the Blue LED signals by the Red LED signals. The two new data sets are split by dA and pp and each data set's ratios were fit with a linear function. The slopes vs time in units of $\mathrm{ADC}_{Blue}/\mathrm{ADC}_{Red}$ month^{-1} are shown in figures 27 and 28.

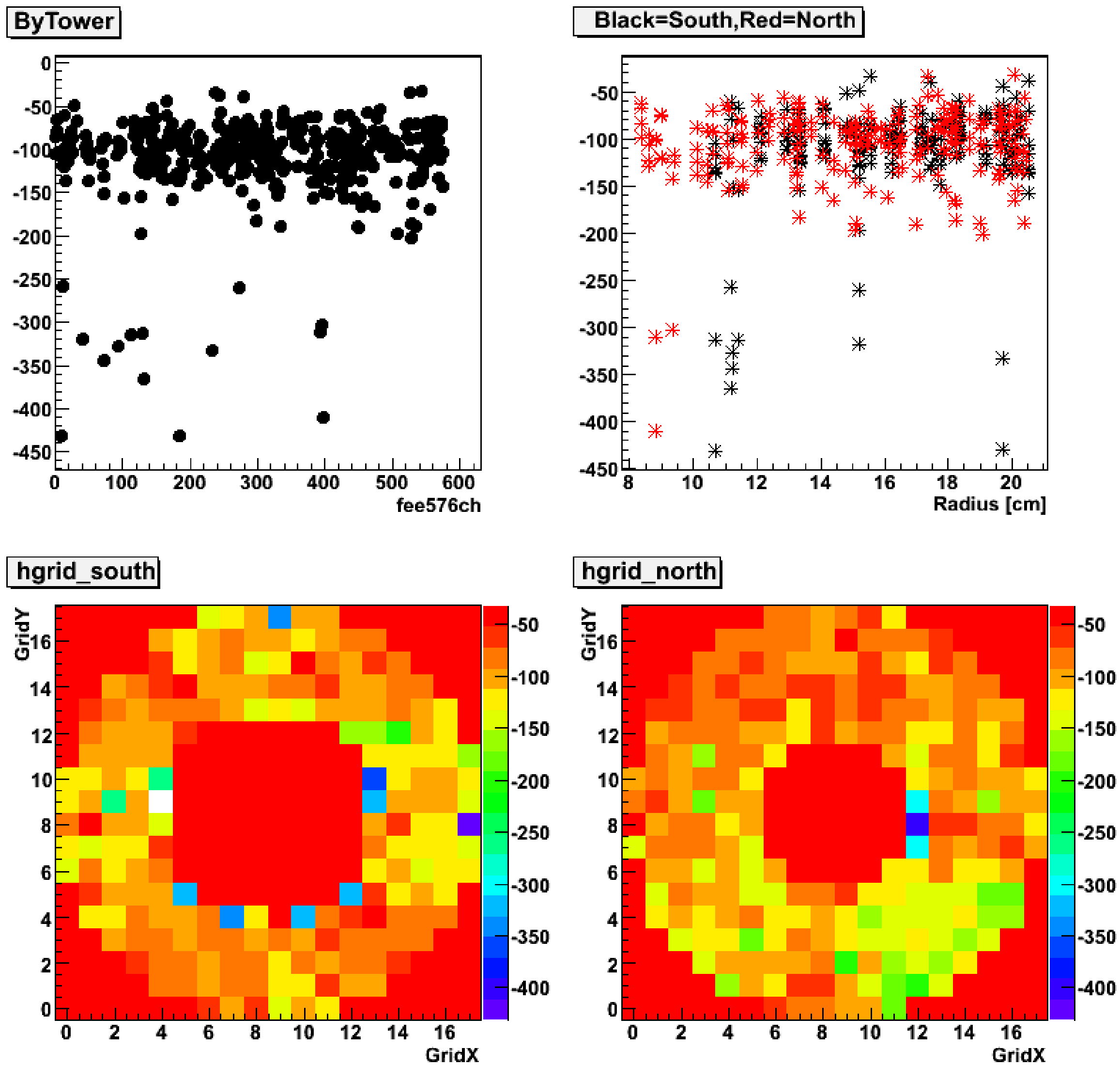


Figure 19: Deuteron Gold, Blue LED - b [ADC / month]

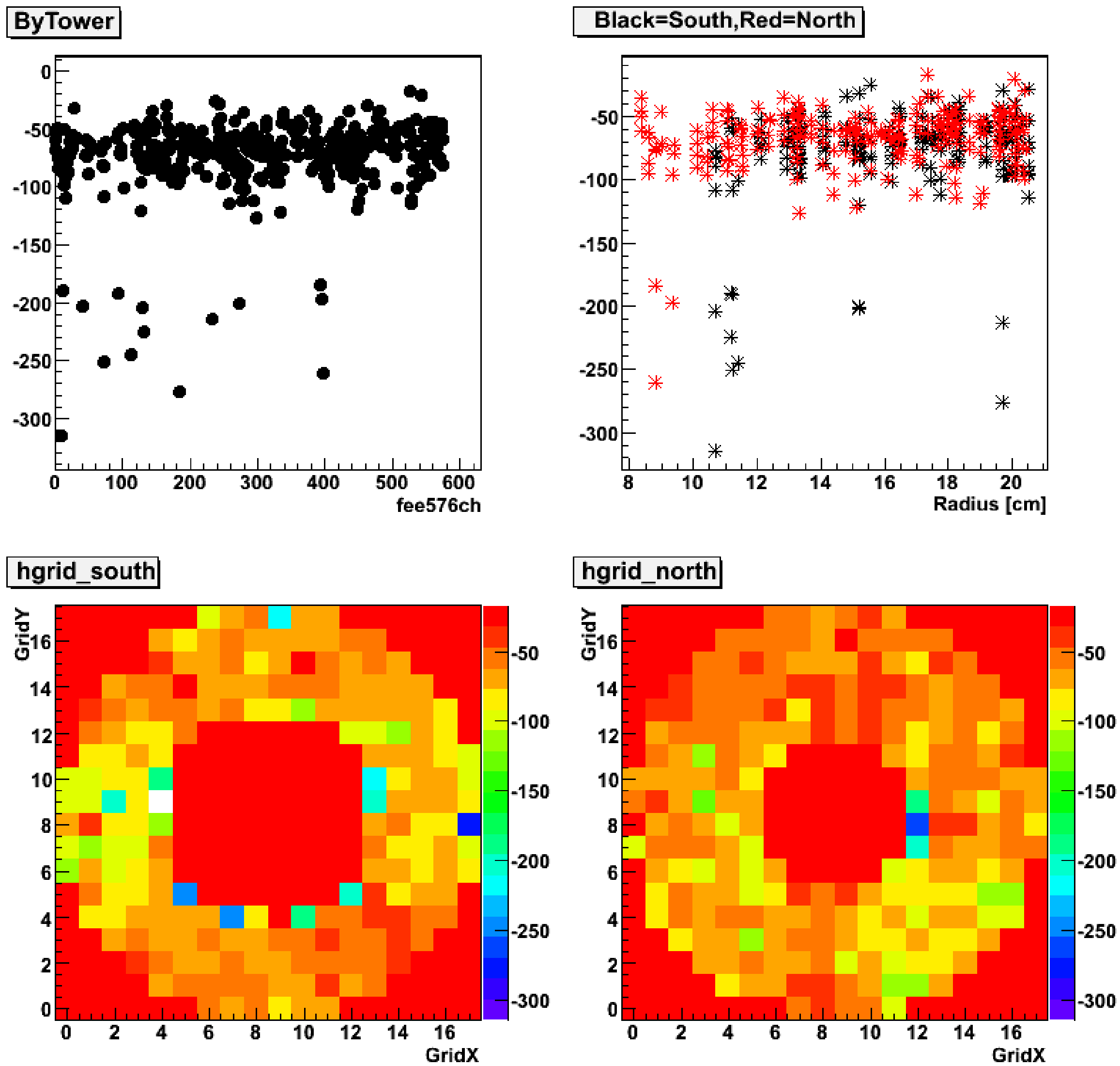


Figure 20: Deuteron Gold, Red LED - b [ADC / month]

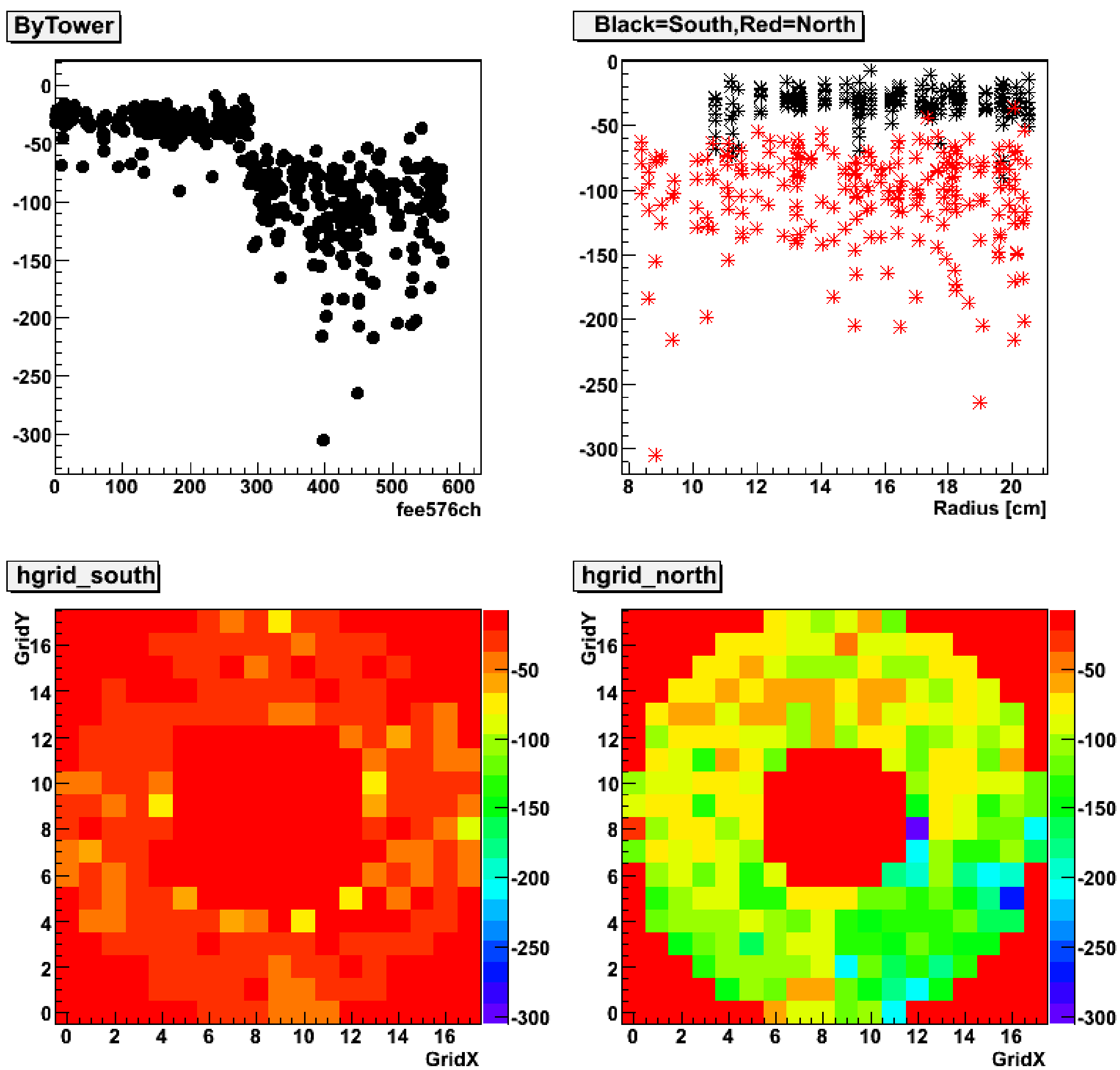


Figure 21: Proton Proton, Blue LED - b [ADC / month].

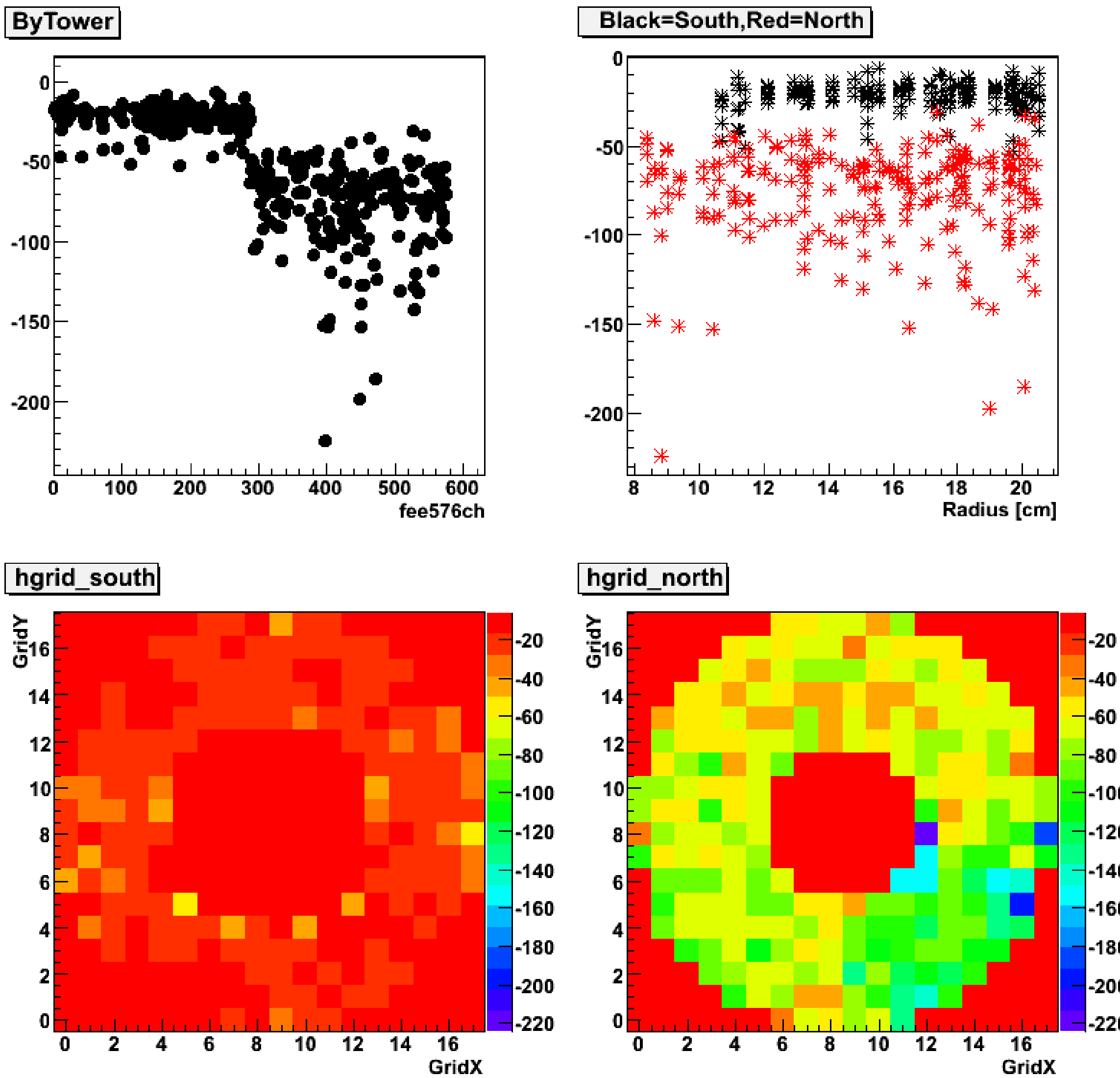


Figure 22: Proton Proton, Red LED - b [ADC / month]

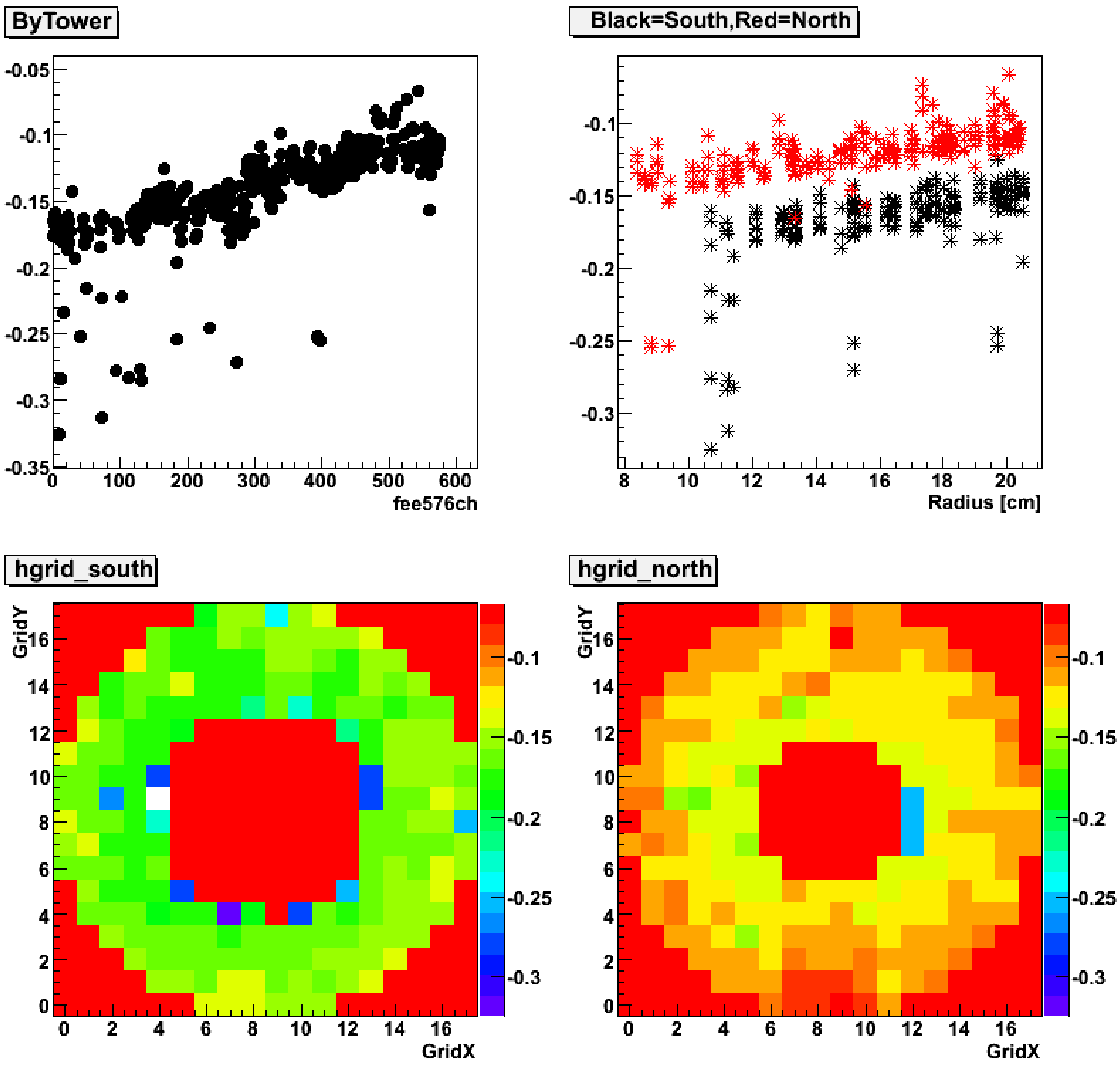


Figure 23: Deuteron Gold, Blue LED – β [% Change / month]

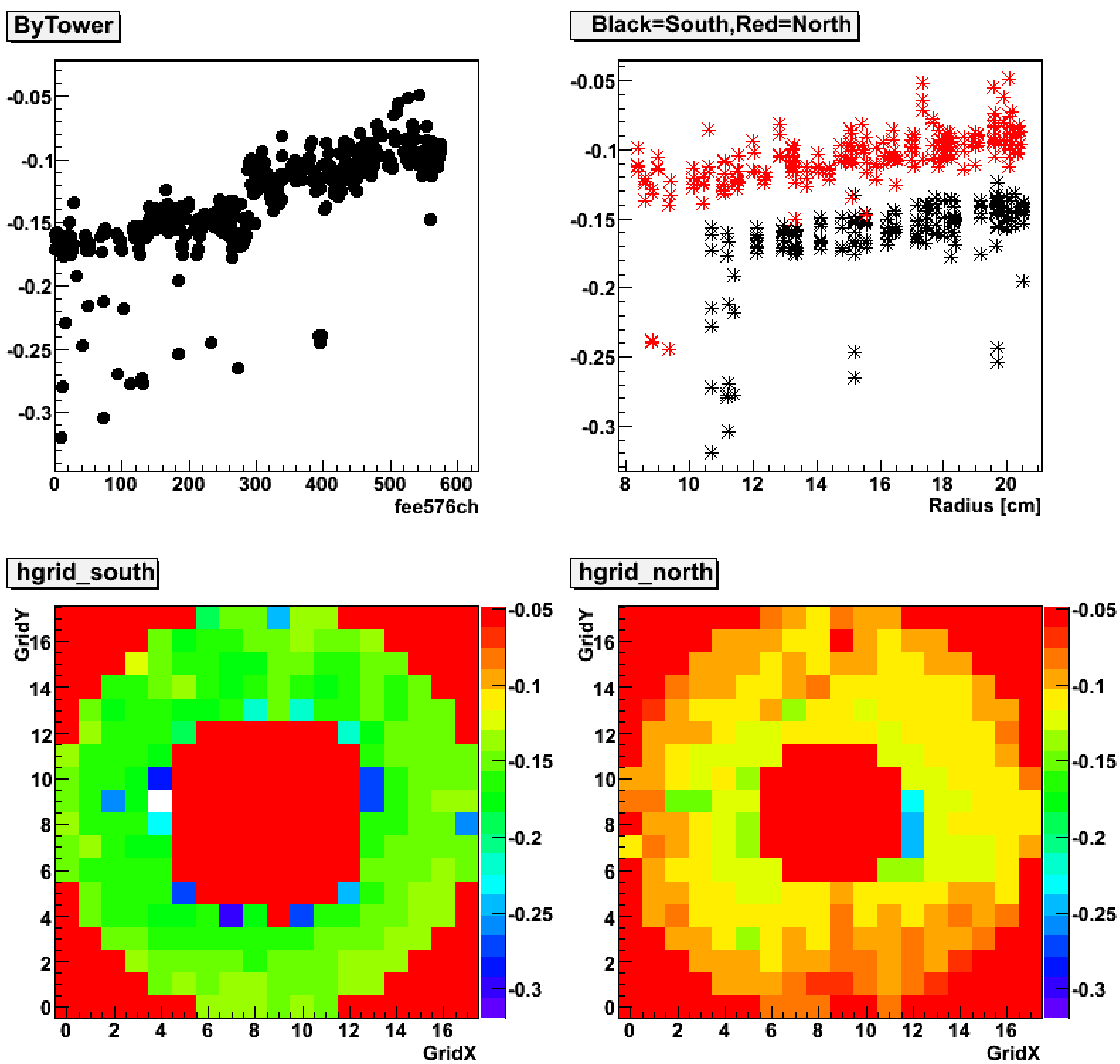


Figure 24: Deuteron Gold, Red LED – β [% Change / month]

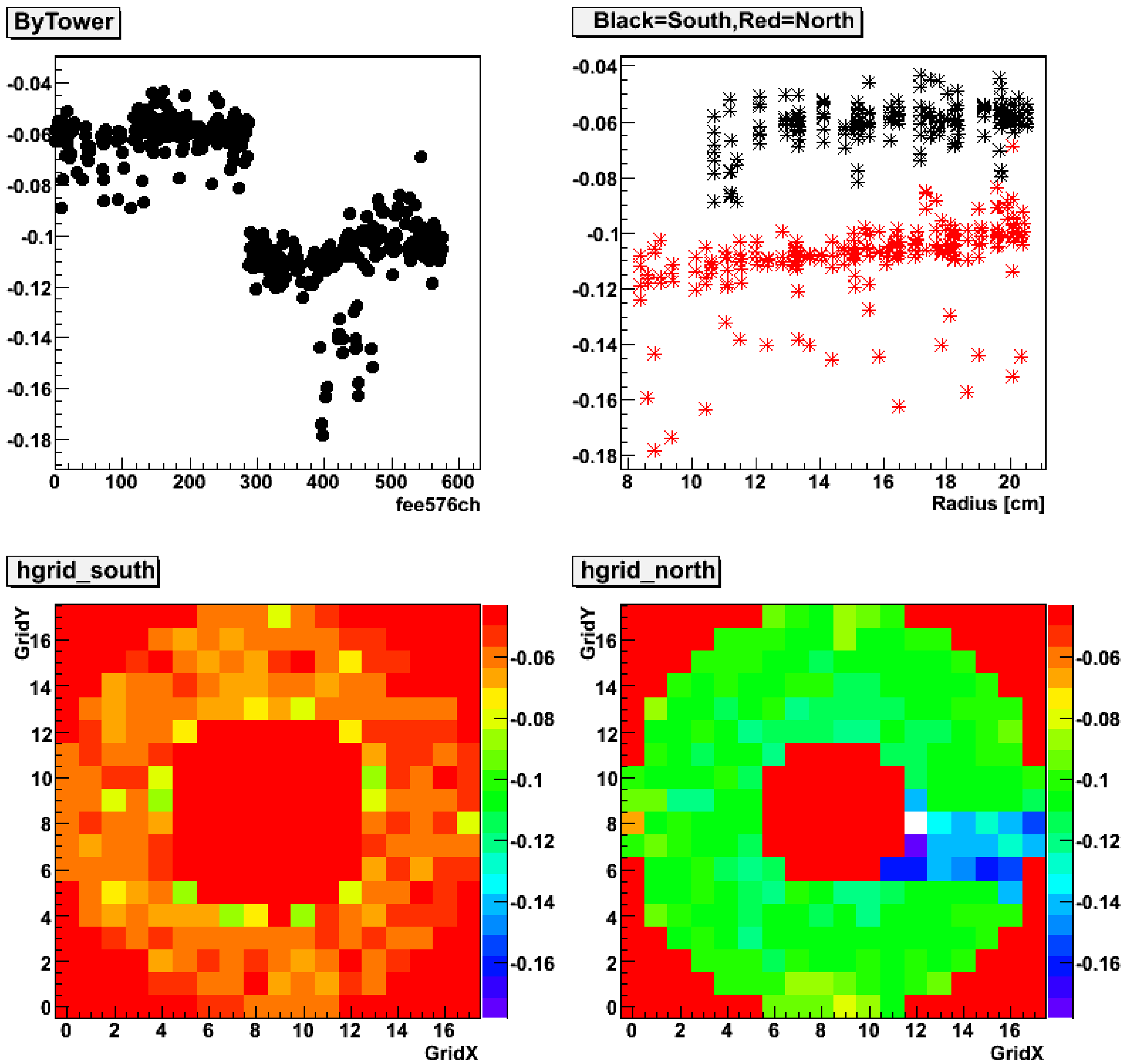


Figure 25: Proton Proton, Blue – β [month^{-1}] The blue stripe across the lower right figure is expected from observations during the run. Its channel map is consistent with a bad driver board. Most likely the simple analysis performed on this data is not suitable to use on this block of channels.

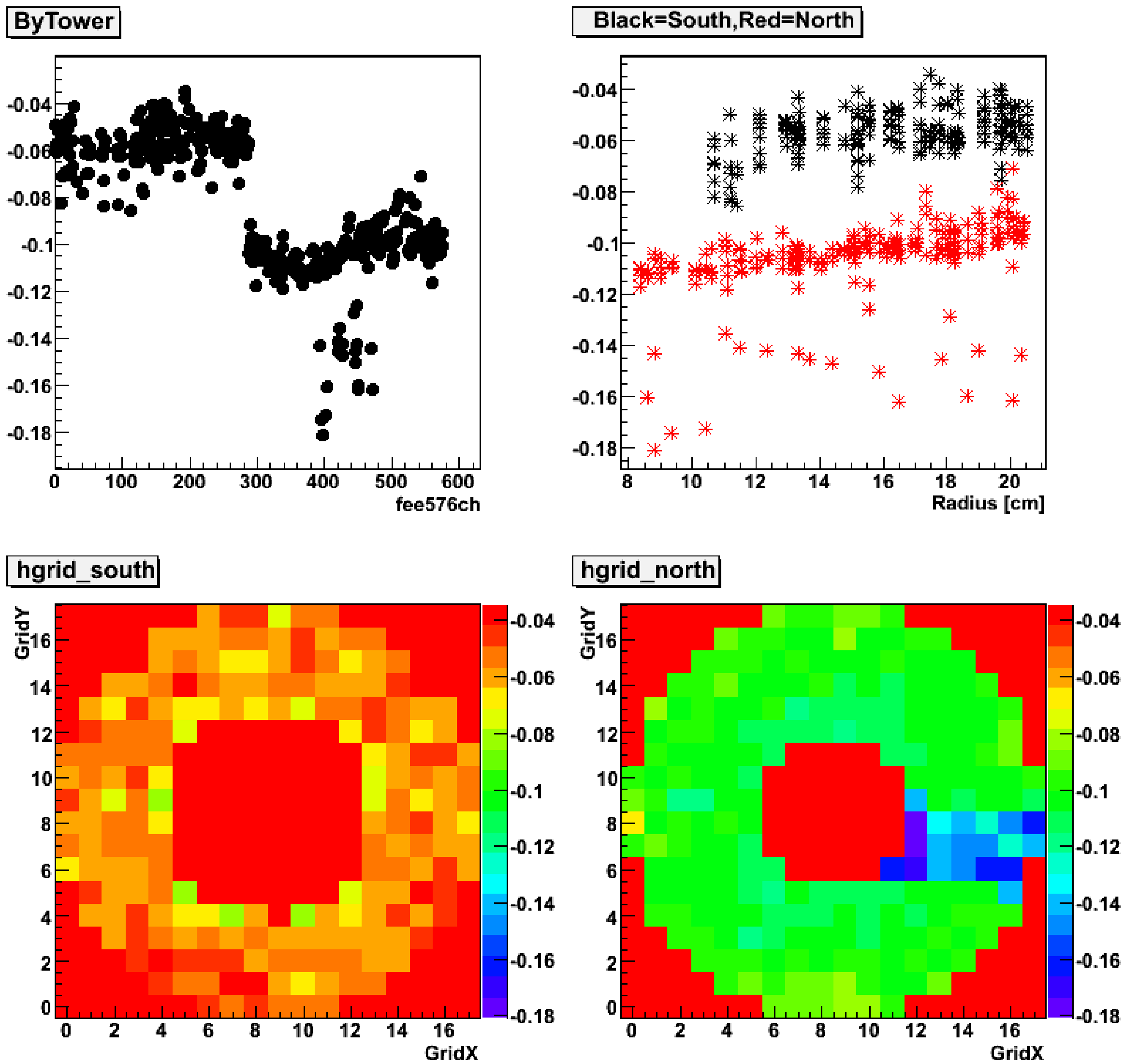


Figure 26: Proton Proton, Red – β [month^{-1}]

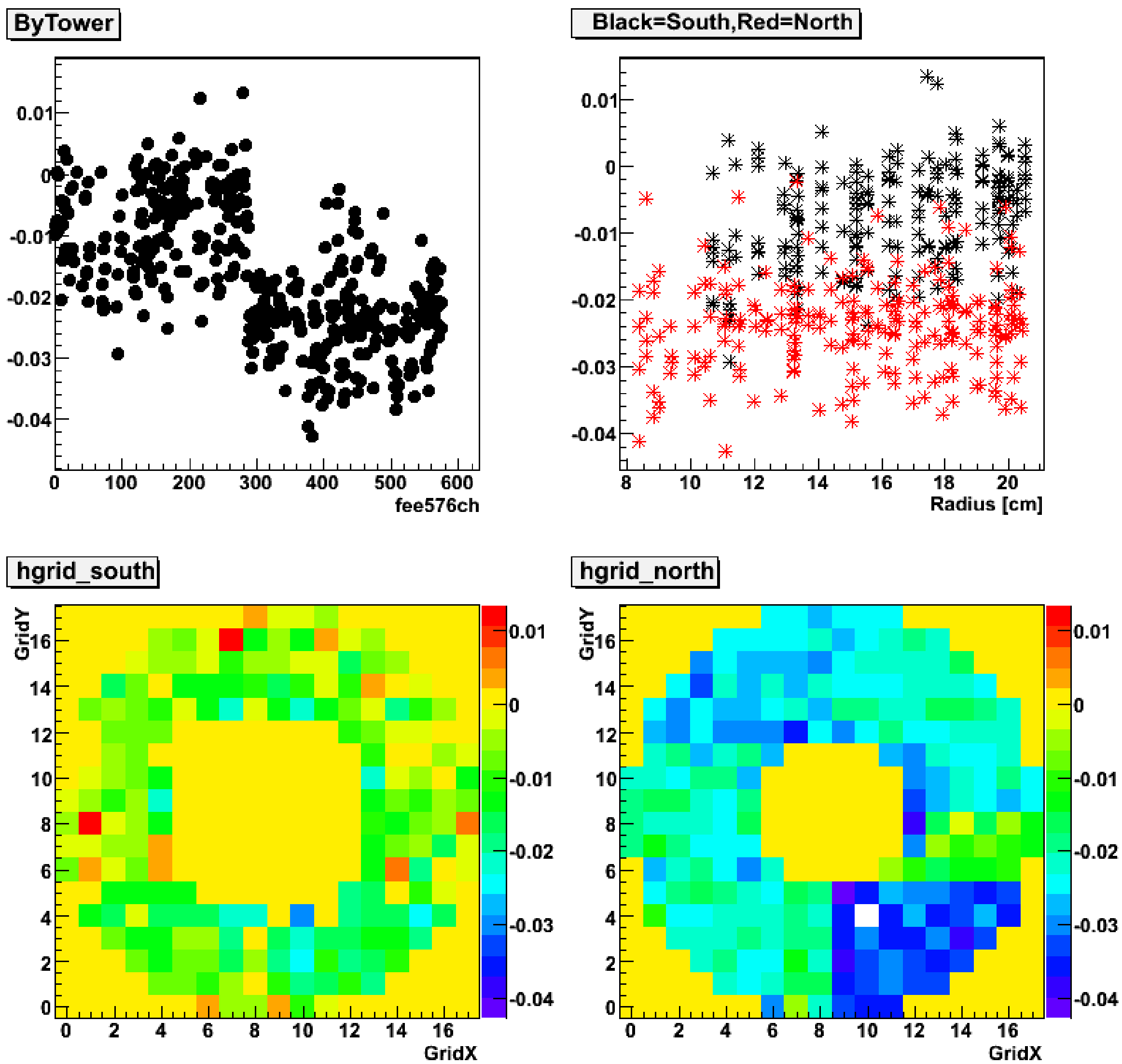


Figure 27: Deuteron Gold, (Blue/Red) Slope [ADC_{Blue}/ADC_{Red} / month]

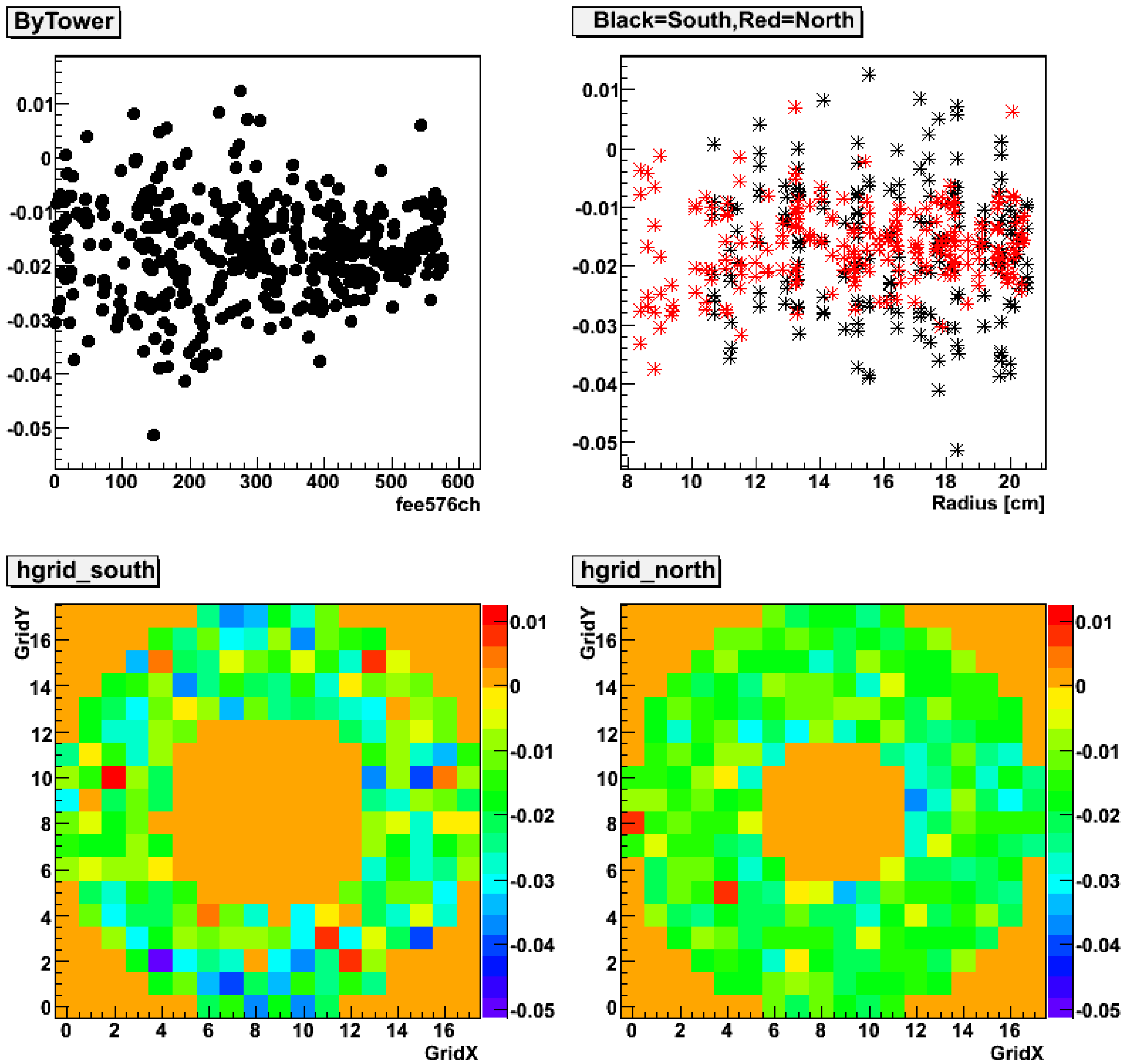


Figure 28: Proton Proton, [Blue/Red] Slope [$\mathrm{ADC}_{Blue}/\mathrm{ADC}_{Red}$ / month]

4.4.4 $(d(\mathbf{ADC}_{Blue}/\mathbf{ADC}_{Red})\ /dt)\ /\ (\mathbf{ADC}_{Blue}/\mathbf{ADC}_{Red})|_{dAStart}$

The slopes found in section 4.4.3 are sensitive to differences between each led pair's relative strength. To remove this sensitivity the percentage change per month was found by dividing the slopes by each tower's ratio evaluated at the start of the dA running period (β)[6] 4.4.2.

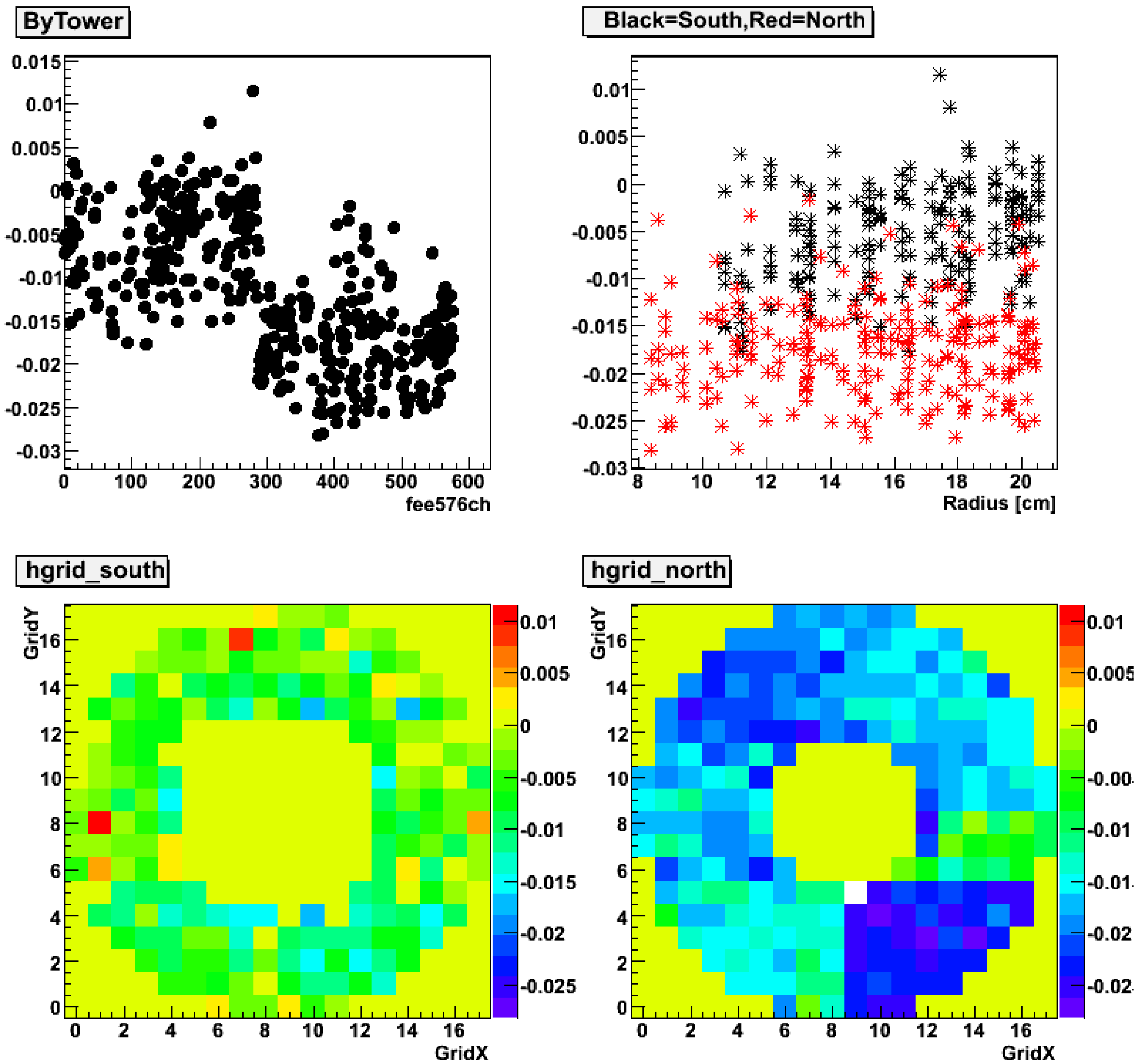


Figure 29: Deuteron Proton, [Blue/Red] Percent Change / month]. The lower-right block of channels map to one led pair.

[6]Note, the value of the ratio at the start of dA was NOT used here! The fit's prediction was used.

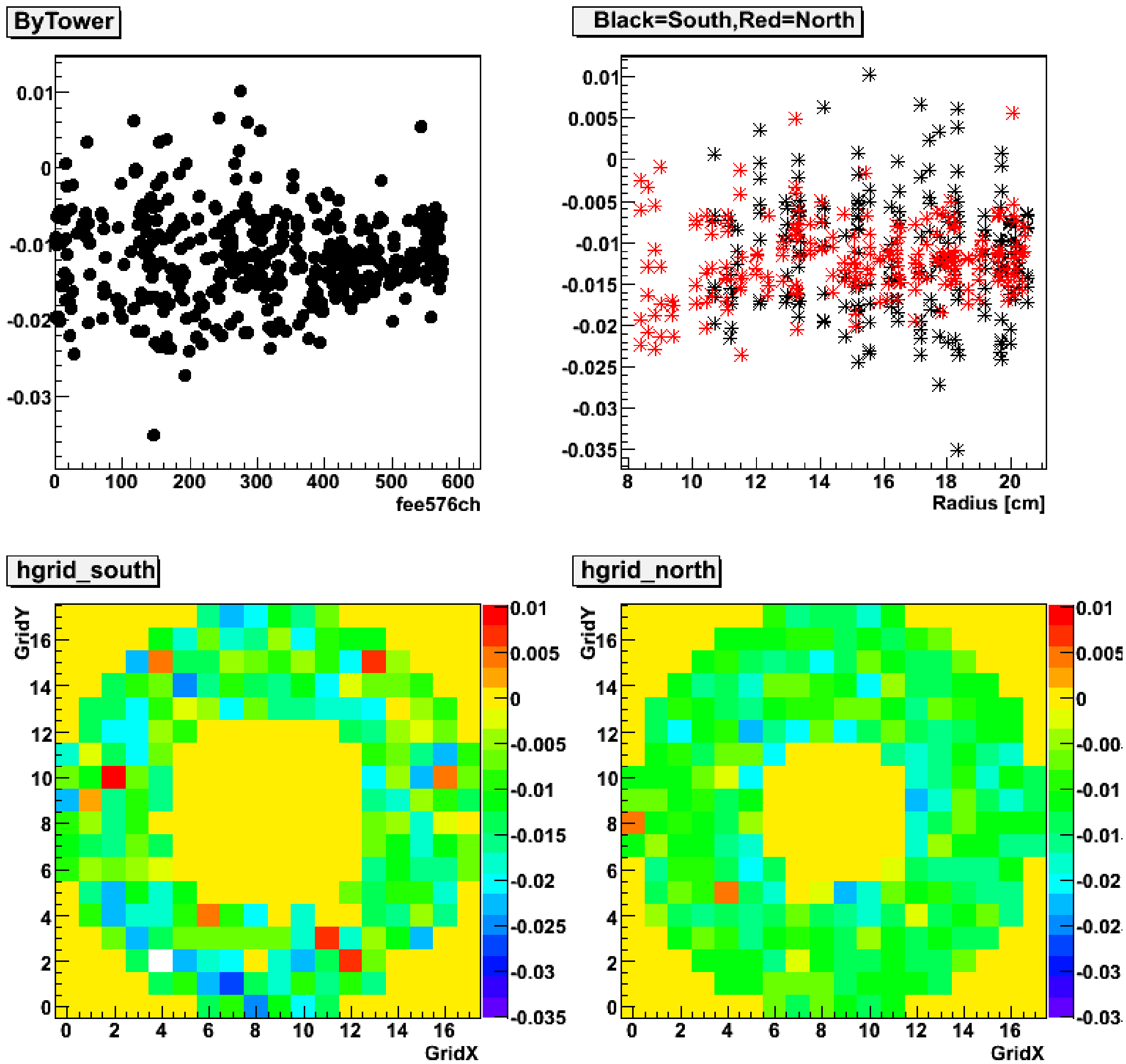


Figure 30: Proton Proton, [Blue/Red] Percent Change / month]

4.5 Discussion

The following table of rough numbers can be eyeballed from the figures in this section.

dA

	Blue		Red		Radius	Ratio	
	South	North	South	North		South	North
ADC/month	-100	-100	-75	-75	Independant	-0.01	-0.025
%ADC/month	-17	-12	-16	-12	Dependant	-0.5	-2

pp

	Blue		Red		Radius	Ratio	
	South	North	South	North		South	North
ADC/month	-30	-100	-25	-75	Independant	-0.02	-0.02
%ADC/month	-6	-11	-6	-10	Dependant	-1.0	-1.5

Some observations from this table:
Blue and Red LED Data:

- The ratio of North dA / South pp percentage change is roughly 1.
- The ratio of South dA / South pp percentage change is roughly 3.
- During the dA portion of the run, the South shows bigger drops than the north, but the South drops less than the North during the pp period of running.

Ratio Data:

- The slope of the ratios seem independant of radius in both dA and pp.

4.6 Speculation

During the dA period of running the south (the gold is moving from north to south) is exposed to higher backgrounds than the north, and as a result shows larger percentage decreases. Then, in the pp running when there are presumably equal doses of radiation, the south shows smaller percentage drops than the North. The difference in drops can be explained by the damage saturating in the South during dA running.

If the damage depends exponentially with irradiation, then presumably the South MPC moves further down the curve in dA running than the North MPC based simply on the its larger β factor. Then, when both sides are exposed to what are presumably equivalent doses of radiation in pp, the β factors are unequal because the South started pp in worse shape than the North.

5 Post-Run 08 LED Run

To check whether the detector recovered from the decreases in signal from Run 08, two LED run were taken several months after the end of run 08 (June 13, 2008). The analysis is slightly different than the run 08 method, but the results should be consistent. Also, only Blue LED data was taken on June 13, 2008.

An important note on this data is that June 13 temperature and the steady state temperature of run 08 are not the same (see figure 31). In general, lowering the temperature increases the measured signals, so the actual recovery is somewhat lower than what figure 32 suggests.

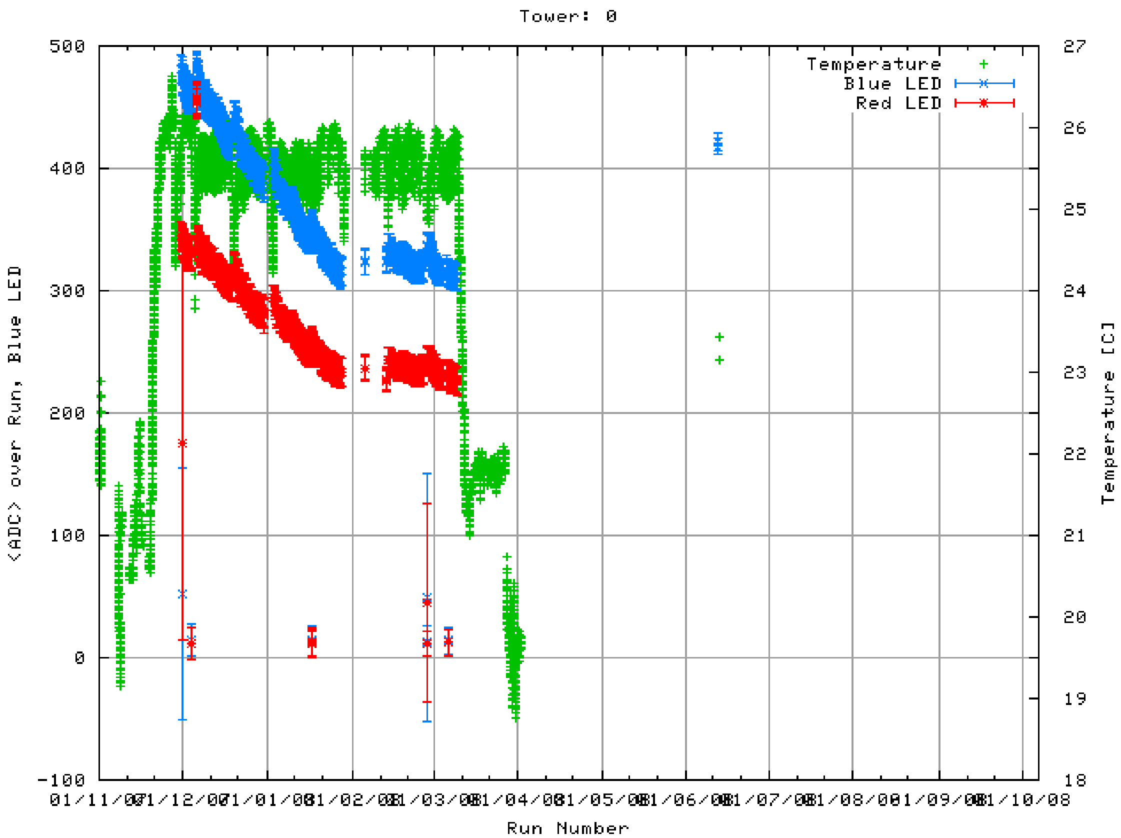


Figure 31: Tower 0: Red and blue points correspond to run averaged ADC's. The color of the points corresponds to the color of the LED. Temperature is shown in green. A similar plot for every tower is available in details/MpcSpecial.pdf

For each tower over run 08 the highest and lowest[7] run averages were found.

[7]The true high and low were not used. The shift crew occasionally forgets to turn on the MPC high voltage so for these runs the measured signals were very low. To get around this the highest 20th and lowest 20th numbers were used instead. For reference, over 900 runs are

These numbers are represented by the vertical bar in figure 32. On the same plot the two June 13 runs are are shown by the solid rectangle on each line. In effect, figure 32 shows a “progress bars” of the recovery for each tower in the MPC.

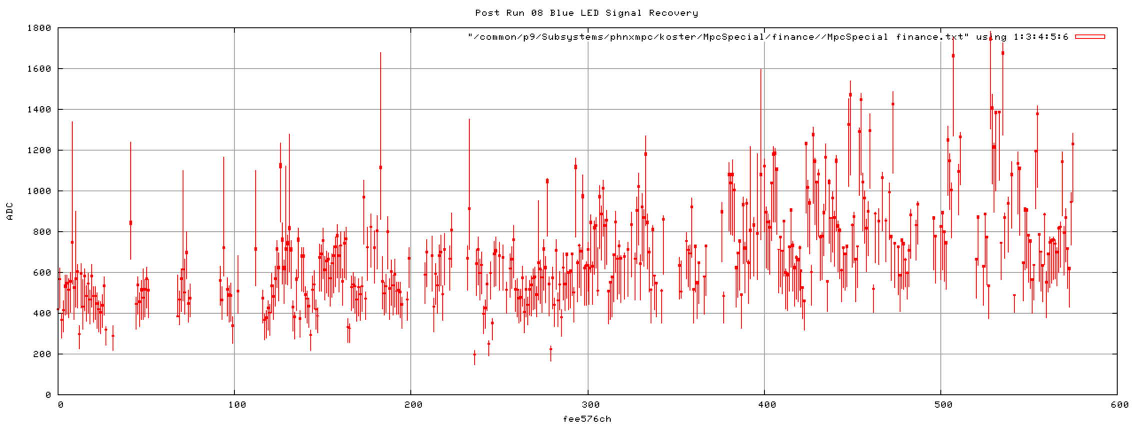


Figure 32: X-Axis: fee576ch, Y-Axis: Run averaged Blue LED signals. The vertical lines are defined by the maximum and minimum values for each tower in Run 08. The rectangles draw on top of each line are the June 13 measurements.

5.1 Temperature Correction

Figure 31 shows that the recent and run 8 temperatures are quite different. To do a rough correction for this effect, a simple study on the run 8 data was performed using the Blue LED data around two time periods when there were sudden decreases in temperature.

The two time periods studied were: Dec 4, 2007 and Dec 19, 2007.

	Low ADC	Hi ADC
December 4, 2007		
Runnumber	246612	247037
Timestamp	1196795055	1196940806
Temp North [C]	26.07	25.54
Temp South [C]	24.72	23.69
December 19, 2007		
Runnumber	248667	248781
Timestamp	1198024865	1198123322
Temp North [C]	25.92	24.78
Temp South [C]	24.95	22.55

The temperatures of each detector are from NMPCADAMSlot0AI02 and SMT1Slot0AI02.

used in this analysis so not much data was cut out.

The percentage increase between the runs Blue LED signals indicated in the table are plotted in figures 33 and 34. However, the percentage change per degree Celsius is a better quantity to calculate in order to apply a correction to the June 13, 2008 data. These numbers are shown in 35 and 36.

The uniformity of the data from December 19, 2007 and the fact that the December 4, 2007 was from the beginning of Run 08 when the detector was still getting tuned suggest that the almost flat correction factor from December 19 can be used for all data. The percentage change per degree Celsius of -0.02 [C^{-1}] will be used.

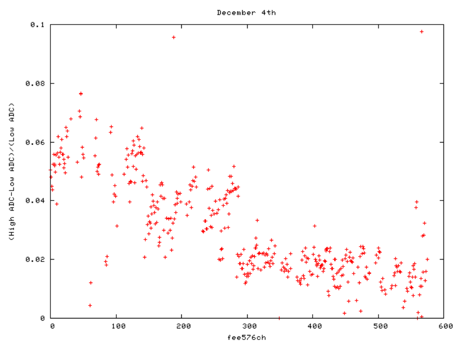


Figure 33: Percent Change between the December 4, 2007 runs

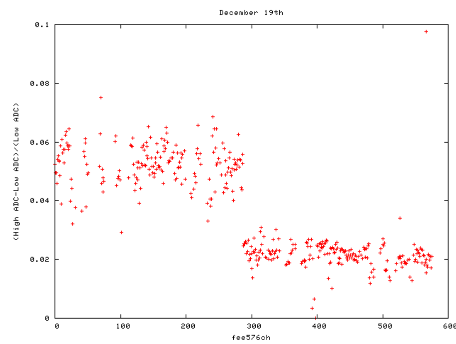


Figure 34: Percent change between the December 19, 2007 runs

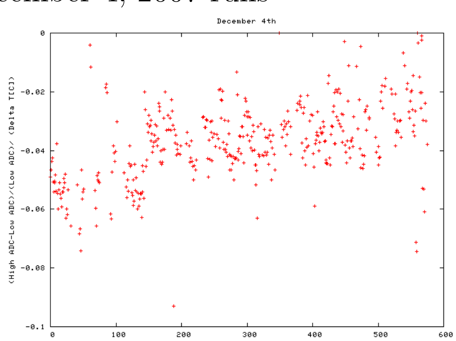


Figure 35: Percent change between the December 4, 2007 runs divided by ΔTemperature

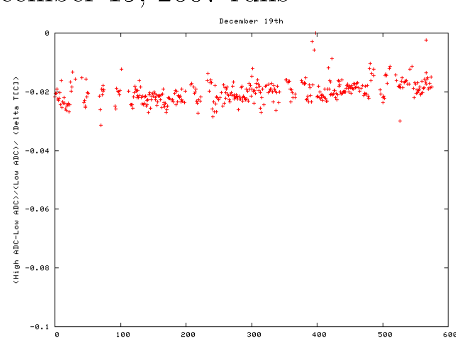


Figure 36: Percent change between the December 19, 2007 runs divided by ΔTemperature

5.2 Temperature Corrected June 13 data

The steady state temperatures for the (North,South) are roughly: (25.5,24.5)[C], the June 13 temperatures are roughly (23,21). Subtracting gives a temperature difference of (-2.5,-3.5). This indicates that we expect the measured signals to be boosted by (5%,7%) and that to correct the measured values we should multiply the measured values by (0.95,0.93) to normalize them to Run 08 steady-state temperatures.

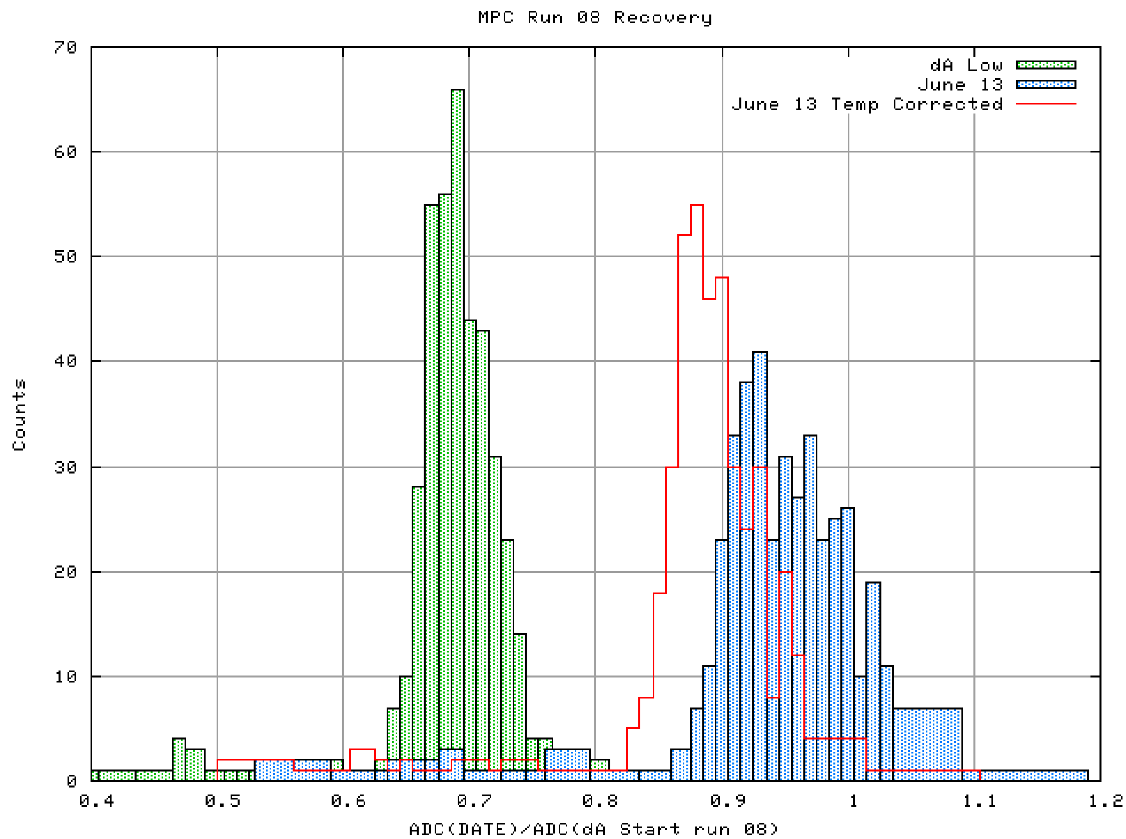


Figure 37: X-axis: ADC(Time)/ADC(High), Y-axis: Counts, where Time={Run 08 Low Value (Green), June 13 (Blue)}. The red line is temperature corrected June 13 data. The shape of the temperature correction changes the shape of the non-corrected June 13 histogram because different temperature corrections are done on each arm: 0.95 North and and 0.93 South.

6 Acknowledgments

After a few days of unsuccessful attempts to take an LED run, Mickey Chiu, Ed Desmond, John Haggerty and Martin Purschke aided in taking the June 13 data.

This note has also benefitted from discussions with Cheng-Yi Chi, Mickey Chiu, Matthias Grosse-Perdekamp, Andrey Kazantsev, Eduoard Kistenev, Kensuke Okada, Chris Pinkenburg and Craig Woody.

A Temperatures

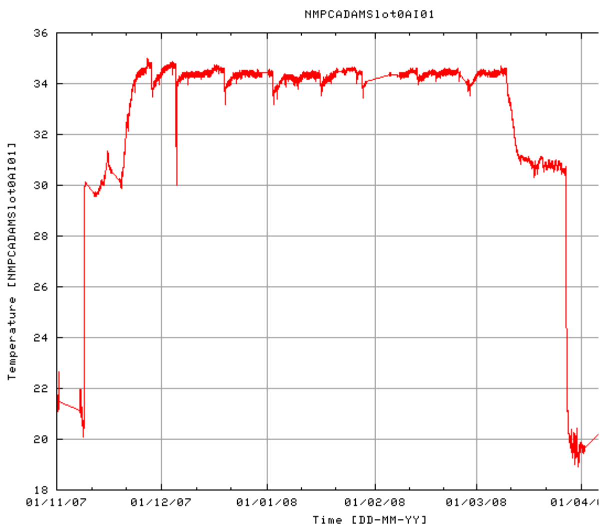


Figure 38: North MPC, Temperature #1

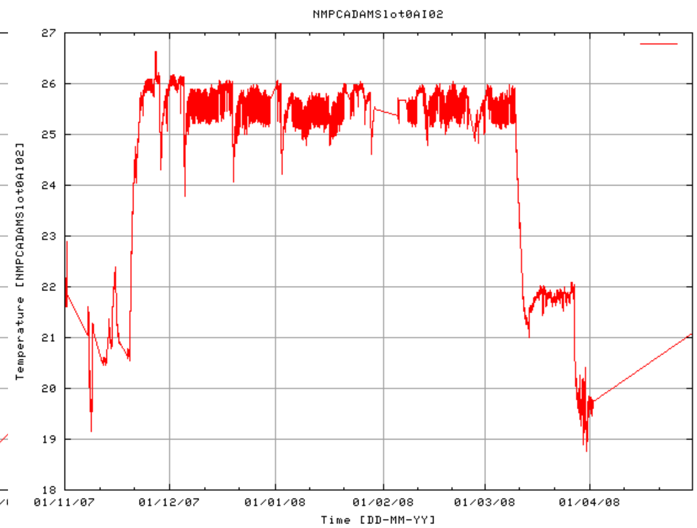


Figure 39: North MPC, Temperature #2

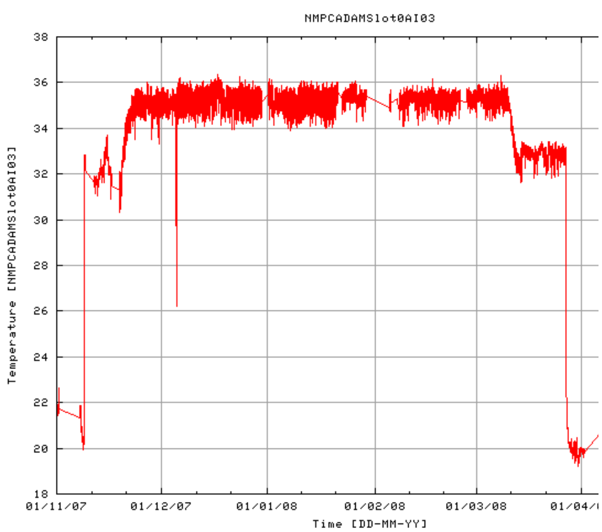


Figure 40: North MPC, Temperature #3

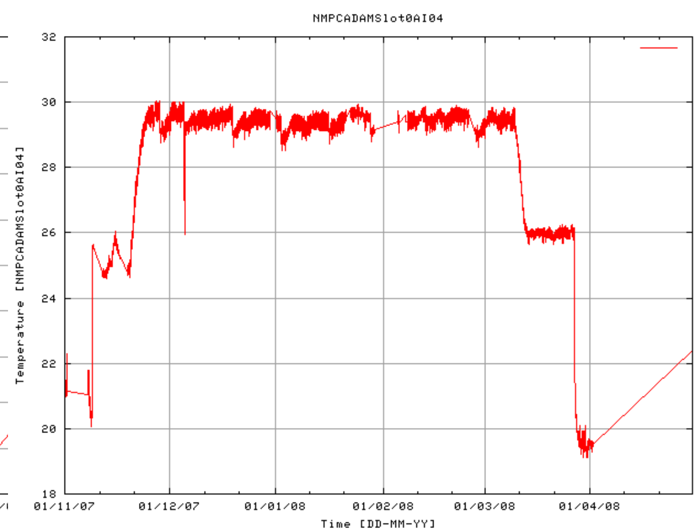


Figure 41: North MPC, Temperature #4

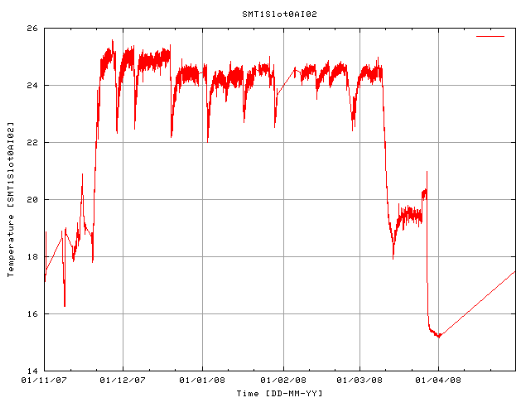


Figure 42: South MPC, Temperature #2

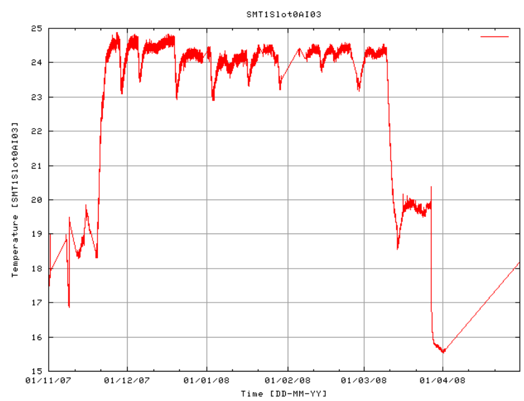


Figure 43: South MPC, Temperature #3

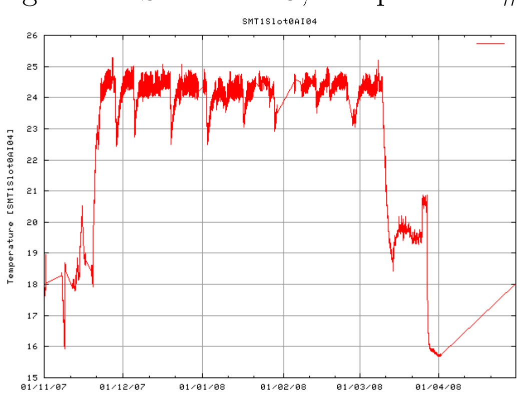


Figure 44: South MPC, Temperature #3